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Skeletal Malocclusion-Related Differences in Lower Facial Soft-Tissue Thickness in Korean Adults Measured With a Facial Scanner

Diferencias Relacionadas con la Maloclusión Esquelética en el Grosor del Tejido Blando Facial Inferior en Adultos Coreanos Medido con un Escáner Facial

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SUMMARY: This study aimed to investigate three-dimensional variations in lower facial soft-tissue thickness across genders and skeletal malocclusion classifications using a structured-light scanner. The null hypothesis was that gender and skeletal malocclusion classification do not significantly affect soft-tissue thickness. A total of 191 Korean adults (94 males, 97 females) aged 20–41 years were included. Soft-tissue thickness at key anatomical landmarks was measured using a structured-light scanner (Morpheus 3D, Seoul, Korea) and analyzed in relation to skeletal malocclusion classifications determined by Steiner's analysis. Statistical analyses included ANOVA, Tukey's Honestly Significant Difference test, the Kruskal–Wallis test, and the Mann–Whitney U test. Significant gender- and malocclusion-based variations in lower facial soft-tissue thickness were identified. Males exhibited greater thickness at Pogonion–Pogonion′, Menton–Menton′, and A Point–A′ Point compared with females. Among skeletal classifications, significant intergroup differences were observed. Class II subjects exhibited greater thickness at Pogonion–Pogonion′ than Class III, whereas Class III subjects showed greater thickness at A Point–A′ Point compared with both Class I and Class II. Gender and skeletal classification significantly influence lower facial soft-tissue thickness, underscoring their relevance in anatomical assessments and maxillofacial treatment planning using structured-light scanning.

KEY WORDS: Soft-tissue thickness; Structured-light scanner; Skeletal malocclusion; Cephalometric analysis; Orthodontic diagnosis.

INTRODUCTION

Accurate evaluation of soft tissue is crucial for precise diagnosis and treatment planning in orthodontics (Siqueira *et al*., 2009). Achieving a harmonious facial profile and optimal occlusion requires consideration of both hard and soft tissues (Ackerman & Proffit, 1997). In particular, three-dimensional (3D) analysis enables the measurement of soft-tissue thickness along the actual surface normals and provides volumetric and asymmetry data that cannot be obtained from conventional two-dimensional (2D) cephalograms alone (Pellitteri *et al*., 2025). Such data are essential for accurately predicting soft-tissue responses to skeletal movements and for simulating treatment outcomes with greater accuracy (Chantaraaumporn *et al*., 2023).

However, conventional lateral cephalometric radiographs, widely used for orthodontic assessments, provide only a two-dimensional view of the relationship between soft and hard tissues, limiting the ability to assess soft-tissue thickness in three dimensions (De Grauwe *et al*., 2019; Kim *et al*., 2022). Cone-beam computed tomography (CBCT) has been introduced as a solution to this limitation, allowing for three-dimensional assessment in orthodontic diagnosis (De Grauwe *et al*., 2019). Nonetheless, concerns regarding radiation exposure associated with CBCT and conventional computed tomography (CT) scans have increased, leading to reluctance among patients (Cao *et al*., 2022). Consequently, the need for noninvasive technologies that minimize radiation exposure while maintaining diagnostic accuracy has become imperative (Perillo *et al*., 2024).

To mitigate radiation exposure concerns, various noninvasive techniques have been introduced for soft-tissue thickness evaluation. Among these, ultrasound imaging has gained attention as a method that evaluates soft-tissue

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thickness without radiation exposure (Cloutier *et al*., 2021). However, it has limitations in terms of accuracy and reproducibility (Garib *et al*., 2010). The primary drawback of ultrasound is the distortion of reflected waves near hard tissues such as bone, making consistent measurement of soft-tissue thickness challenging. Furthermore, the anatomical complexity and curvature of facial structures further complicate the acquisition of accurate three-dimensional data (Giangrossi *et al*., 2022).

Recent advancements in digital imaging and image-processing technology have significantly enhanced diagnostic accuracy and treatment planning in orthodontics (Perillo *et al*., 2024). In particular, the development of 3D scanning technology has enabled precise analysis of complex facial structures while minimizing radiation exposure (Pellitteri *et al*., 2023). Three-dimensional scanning converts the surface morphology of a subject into a digital format using numerous coordinate points to create a three-dimensional image (Seo *et al*., 2024). This technique employs structured light, laser, or stereovision technology to capture depth information, thereby allowing three-dimensional assessment of soft tissues, which substantially improves diagnostic precision compared with conventional two-dimensional imaging (Kim *et al*., 2022). Structured-light scanners, in particular, provide high-resolution measurements, enable assessment along curved surfaces, and facilitate asymmetry analysis, offering practical advantages over CBCT and ultrasound for repeated, radiation-free evaluations (Lee *et al*., 2017; Pellitteri *et al*., 2023). Such advancements enable more accurate predictions of facial changes before and after treatment, ultimately contributing to improved patient satisfaction and treatment outcomes.

To address the limitations of traditional radiographic methods in orthodontic diagnosis, structured-light scanners, such as facial scanners, have emerged as a promising alternative. These scanners provide high-resolution soft-tissue analysis without radiation exposure and allow for precise evaluation of soft-tissue thickness using 3D imaging technology (Lee *et al*., 2017). By overcoming the shortcomings of conventional radiographic techniques, facial scanners serve as a valuable diagnostic tool that ensures accurate evaluation while minimizing radiation exposure. Given these advantages, analysis of soft-tissue thickness obtained through facial scanning is expected to yield clinically relevant findings. In particular, the thickness of soft tissues in the lower facial region, including the chin and anterior maxilla, plays a crucial role in determining facial esthetics during orthodontic treatment. Moreover, soft-tissue thickness may vary according to different skeletal malocclusion classifications (Arnett & Gunson, 2004). Therefore, accurately assessing differences in soft-tissue thickness in the chin and anterior maxilla across malocclusion classifications is essential for effective orthodontic treatment planning (Kilic *et al*., 2010).

Despite the clinical importance of soft-tissue thickness, there remains a paucity of research evaluating soft-tissue thickness in the chin and anterior maxilla according to different skeletal malocclusion classifications among Korean orthodontic patients (Park *et al*., 2023). Therefore, the present study aimed to investigate differences in soft-tissue thickness in the chin and anterior maxilla according to sex and skeletal malocclusion classification using a facial scanner. In addition, this study tested the null hypothesis that sex and skeletal malocclusion classification do not significantly influence soft-tissue thickness in these anatomical regions. Through this investigation, we sought to establish the feasibility of utilizing facial scanning as a reliable, radiation-free method for soft-tissue thickness assessment in orthodontic treatment planning.

MATERIAL AND METHOD

Study Subjects

Ethical approval was obtained from the Institutional Review Board (IRB) of Chosun University Dental Hospital (CUDHIRB 2405 003), and all participants provided written informed consent before participation in this study. A total of 191 Korean patients (94 males and 97 females) who visited Chosun University Dental Hospital for orthodontic diagnosis between 2021 and 2023 were included. The study subjects were adults with permanent dentition, aged 20–41 years (mean age: 25.5 years). Patients with conditions affecting the maxilla or mandible, such as cleft lip and palate, were excluded. Among the 191 participants, 63 were classified as skeletal Class I (31 males and 32 females), 67 as Class II (33 males and 34 females), and 61 as Class III (30 males and 31 females) based on cephalometric evaluation.

Data Acquisition

Three-dimensional facial soft-tissue data were acquired using a structured-light facial scanner (Morpheus 3D Dental Solution 3.0, Morpheus Co., Seoul, Korea; accuracy <0.1 mm). Participants were seated in a natural head position with the Frankfort horizontal plane parallel to the floor, lips relaxed, and teeth in maximum intercuspation (intercuspal position, ICP). Raw 3D mesh data were processed to remove noise and fill surface holes, and predefined soft-tissue landmarks, including Nasion (N′), Subnasale (Sn), Pogonion (Pg′), and Gnathion (Gn′), were manually identified. Lateral cephalometric radiographs were also obtained for all participants using a calibration scale during imaging to correct for magnification. The cephalograms were converted to a 1:1 ratio using the Morpheus 3D Dental Solution software. Registration of the 3D facial surface to the 2D cephalometric image was performed using common soft-tissue landmarks (N′, Sn, Pg′) for initial landmark-based alignment, followed by a surface-based iterative closest point (ICP) algorithm for refinement. The mean registration error was 0.35 mm, which is within the ±0.5 mm range reported in previous validation studies (Pellitteri *et al*., 2023). In conventional lateral cephalograms, landmarks such as Pg′ and Menton (Me′) may be underestimated because of projection errors and variation in head orientation (Yildirim *et al*., 2011). In contrast, 3D facial scanners enable these landmarks to be precisely identified in true spatial coordinates, allowing accurate measurement of soft-tissue thickness along the actual surface normals and eliminating projection-related inaccuracies (Major *et al*., 2024). This integration of 3D surface data with cephalometric images effectively compensates for the inherent limitations of 2D-based measurements and enables more reliable assessment of soft-tissue thickness along the true curved surfaces of the face.

Data Measurement

Skeletal malocclusion classification was determined using Steiner's analysis (Park *et al*., 2023). The reference plane in Steiner's analysis is the sella–nasion (SN) plane, which connects the sella (S), the midpoint of the sella turcica, and the nasion (N), the most anterior point of the frontonasal suture. The skeletal relationship of the maxilla and mandible to the cranial base was assessed using the following angular measurements: the SNA angle (Sella–Nasion–A Point), which represents the position of the maxilla relative to the cranial base; the SNB angle (Sella–Nasion–B Point), which indicates the mandibular position relative to the cranial base; and the ANB angle (A Point–Nasion–B Point), which determines the anteroposterior skeletal relationship between the maxilla and mandible. Subjects were classified into skeletal malocclusion groups according to the ANB angle: Class I (1.0°–3.0°), Class II (>4.0°), and Class III (<0.0°). Subjects with borderline ANB values between 3.0°–4.0° or between 0.0°–1.0° were excluded to minimize classification ambiguity. These borderline ranges may include individuals with transitional skeletal patterns, which could compromise the homogeneity of each skeletal malocclusion group. For each subject, soft-tissue thickness of the chin and anterior maxilla was measured (Fig. 1). Skeletal and soft-tissue landmarks from lateral cephalometric radiographs were used for measurements. To evaluate chin thickness, four anatomical landmarks were selected (Yildirim *et al*., 2011).

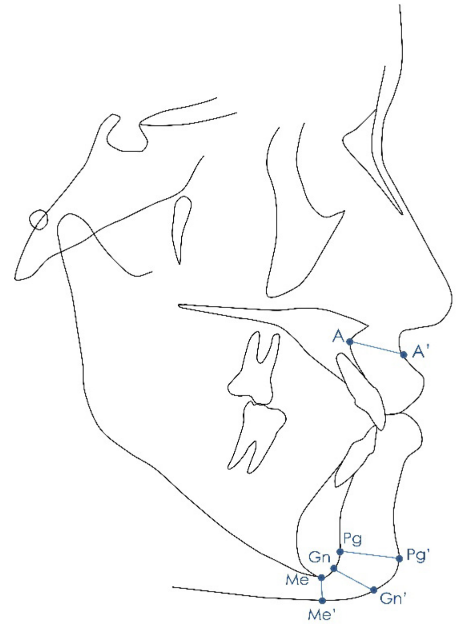

Fig. 1. Distance between skeletal and soft-tissue landmarks.

- Pogonion (Pg): The most anterior point of the mandibular symphysis, representing the central point of mandibular projection.
- Pogonion′ (Pg′): The corresponding soft-tissue landmark, representing the outermost soft-tissue surface at Pogonion (Yildirim *et al*., 2011).
- Gnathion (Gn): The most inferior and anterior point of the mandible.
- Gnathion′ (Gn′): The corresponding soft-tissue landmark at Gnathion.
-Menton (Me): The most inferior midline point of the mandibular symphysis.
-Menton′ (Me′): The corresponding soft-tissue landmark at Menton (Yildirim *et al*., 2011).

For anterior maxillary soft-tissue thickness measurement, A Point (A) was used as a reference:

- A Point (A): The deepest concavity on the anterior maxilla, representing the anterior projection of the maxilla.
- A′ Point (A′): The corresponding soft-tissue landmark, representing the outermost soft-tissue surface at A Point (Yildirim *et al*., 2011).

Measurement of soft-tissue thickness at each landmark. Distances were measured along the surface normal between corresponding skeletal and soft-tissue points: Pg–Pg′ (Pogonion), Gn–Gn′ (Gnathion), Me–Me′ (Menton), and A–A′ (Point A). The skeletal landmarks were identified on lateral cephalometric radiographs, and the soft-tissue points were located on the merged 3D facial scan. Measurements were standardized relative to the Frankfort horizontal (FH) plane.

- Pg–Pg′: Distance between the skeletal landmark Pogonion and the soft-tissue landmark Pogonion′.
- Gn–Gn′: Distance between the skeletal landmark Gn and its corresponding soft-tissue point (Gn′), measured parallel to the FH plane.
- Me–Me′: Distance between the skeletal landmark Menton and the soft-tissue landmark Menton′.
- A–A′: Distance between the skeletal landmark A Point and soft-tissue landmark A′ Point.

Soft-tissue thickness was determined by measuring the shortest distance between the skeletal and corresponding soft-tissue landmarks. All measurements were taken twice by the same examiner to ensure reliability. The magnitude of random error was calculated using Dahlberg's formula ($S^2 = \Sigma d^2/2n$), where S^2 represents the error variance and d refers to the difference between two repeated measurements of the same variable. All measurements were performed using Morpheus 3D simulation software (Seoul, Korea).

Statistical Analysis

The following statistical methods were used in this study:

1. Normality Test: The Shapiro–Wilk test was performed to assess the normality of each variable. A p-value greater than 0.05 was considered indicative of normality. Most variables exhibited a normal distribution; however, some variables in specific sex or malocclusion subgroups did not satisfy the assumption of normality. Accordingly, both parametric tests (ANOVA and Tukey's Honestly Significant Difference [HSD] test) and nonparametric tests (Kruskal–Wallis test and Mann–Whitney U test) were applied selectively based on distribution characteristics.

2. Sex Comparison Analysis: Comparisons were made between males and females within each skeletal malocclusion group (Class I, II, and III) as well as across the entire sample. For each variable (Pg–Pg′, Gn–Gn′, Me–Me′, A–A′), an independent-samples t-test was conducted if the normality assumption was satisfied. If normality was not met, the Mann–Whitney U test was performed to compare differences between groups.

3. Comparison Among Skeletal Malocclusion Groups: Differences in soft-tissue thickness among Class I, Class II, and Class III malocclusions were analyzed, including subgroup analyses by sex. For normally distributed data, ANOVA and Tukey's HSD test were used, whereas for nonnormally distributed data, the Kruskal–Wallis test and Mann–Whitney U test were applied. The choice of statistical test was determined according to the results of the normality test.

RESULTS

Random error, calculated using Dahlberg's formula, ranged from 0.0427 mm (Gn–Gn′) to 0.0828 mm (Pg–Pg′), indicating high measurement reliability (all errors <0.1 mm).

1. Soft Tissue Thickness Differences by Sex.

As shown in Table I, significant sex-based differences were observed. Males exhibited greater soft-tissue thickness than females at Pg–Pg′, Me–Me′, and A–A′, whereas no significant difference was noted at Gn–Gn′.

Table I. Comparison of means between sexes and statistical test results within each skeletal classification (mm).

Variables / Skeletal Malocclusion	Class I Male	Class I Female	P-value	Class II Male	Class II Female	p-value
Pg–Pg′	12.3 ± 2.5	13.6 ± 1.6	0.034*	13.8 ± 2.1	13.5 ± 3.0	0.745
Gn–Gn′	9.7 ± 2.5	10.4 ± 2.1	0.202	10.3 ± 3.1	9.9 ± 2.8	0.840
Me–Me′	8.4 ± 1.9	9.5 ± 2.6	0.070	9.2 ± 2.2	8.4 ± 2.2	0.004**
A–A′	13.5 ± 2.1	15.8 ± 2.1	<0.001*	15.4 ± 1.9	13.7 ± 2.4	0.003**

Variables / Skeletal Malocclusion	Class III Male	Class III Female	P-value	All Male	All Female	P-value
Pg–Pg′	12.8 ± 2.3	12.1 ± 1.6	0.226	13.3 ± 2.1	12.7 ± 2.5	0.018*
Gn–Gn′	10.4 ± 2.6	10.7 ± 2.7	0.603	10.4 ± 2.6	10.1 ± 2.7	0.659
Me–Me′	9.4 ± 2.5	9.0 ± 2.2	0.567	9.6 ± 2.4	8.6 ± 2.1	0.004**
A–A′	16.7 ± 2.1	14.2 ± 2.1	<0.001*	16.0 ± 2.1	13.8 ± 2.2	<0.001***

Note. Values are mean ± standard deviation. Significance was determined with independent-samples t-test and Mann–Whitney U test; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

- In skeletal Class I, males showed significantly greater thickness at Pg–Pg′ (p = 0.034) and A–A′ (p < 0.001) compared with females.
- In Class II, males had significantly greater thickness at Me–Me′ (p = 0.004) and A–A′ (p = 0.003) than females.
- In Class III, significant differences were observed only at A–A′ (p < 0.001), with males exhibiting greater thickness than females.

2. Soft Tissue Thickness Differences by Skeletal Malocclusion

Table II summarizes differences across malocclusion groups. Significant intergroup variation was noted for Pg–Pg′ (p = 0.009) and A–A′ (p = 0.048), whereas no significant differences were observed for Gn–Gn′ (p = 0.547) or Me–Me′ (p = 0.731).

- Pg–Pg′ was significantly thicker in Class II than in Class III.
- A-A′ was significantly thicker in Class III compared with both Class I and Class II.

3. Combined Effects of Sex and Skeletal Malocclusion

Detailed comparisons by sex within each skeletal classification are presented in Table III.

- Pg–Pg′: Class I males had significantly greater soft-tissue thickness than Class I and Class III females (p = 0.005). Both Class II males and females had greater soft-tissue thickness than Class III females.
- Me–Me′: Class II males exhibited greater thickness than Class I and Class II females (p = 0.032).
- A–A′: Class I and Class III males showed greater thickness than females across all skeletal groups (p < 0.001).

Table II. Comparison of means (mm) and statistical significance test results for variables by malocclusion class.

Variables / Skeletal Malocclusion	Pg–Pg′	Gn–Gn′	Me–Me′	A–A′
Class I	12.9 ± 2.2[a]	10.0 ± 2.4	8.9 ± 2.3	14.5 ± 2.3[c]
Class II	13.6 ± 2.6[b]	10.1 ± 2.9	9.1 ± 2.3	14.2 ± 2.3[d]
Class III	12.4 ± 2.0[b]	10.5 ± 2.6	9.2 ± 2.3	15.8 ± 2.5[cd]
P-value	0.009**	0.547	0.731	0.048*

Note. Values are mean ± standard deviation (mm). Mean values with the same superscript letters within a row are significantly different from each other. Significance was determined with ANOVA and Tukey's HSD test, as well as Kruskal–Wallis and Mann–Whitney U tests. *p < 0.05, **p < 0.01.

Table III. Comparison of means (mm) and statistical significance test results for variables among skeletal malocclusion classes, stratified by sex

Skeletal Malocclusion	Pg–Pg′	Gn–Gn′	Me–Me′	A–A′
Class I Male (n = 31)	13.55 ± 1.75[ab]	10.42 ± 2.13	9.47 ± 2.57	15.78 ± 2.05[abc]
Class I Female (n = 32)	12.34 ± 2.52[acd]	9.65 ± 2.53	8.40 ± 1.92[a]	13.47 ± 2.06[ade]
Class II Male (n = 33)	13.75 ± 2.10[ce]	10.27 ± 3.07	9.92 ± 2.19[ab]	15.35 ± 1.89[d]
Class II Female (n = 34)	13.50 ± 2.98[df]	9.91 ± 2.84	8.35 ± 2.16[b]	13.66 ± 2.39[bf]
Class III Male (n = 30)	12.75 ± 2.34	10.37 ± 2.56	9.35 ± 2.50	16.73 ± 2.13[efg]
Class III Female (n = 31)	12.13 ± 1.55[bef]	10.72 ± 2.68	9.01 ± 2.17	14.17 ± 2.11[cg]
P-value	0.005**	0.691	0.032*	0.0001***

Note. Values are mean ± standard deviation (mm). Mean values with the same superscript letters within a row are significantly different from each other. Significance was determined with ANOVA and Kruskal–Wallis tests; *p < 0.05, **p < 0.01, ***p < 0.001

DISCUSSION

This study utilized the Morpheus structured-light facial scanner to acquire and analyze 3D soft-tissue data without radiation exposure, providing valuable information for orthodontic diagnosis. Conventional imaging methods such as CBCT and ultrasound have been widely used to assess soft and hard tissues, but both have limitations. CBCT is highly effective for evaluating hard tissues, but it has limited accuracy for soft-tissue assessment and involves radiation exposure as well as high costs (Mozzo *et al*., 1998; Brüllmann & Schulze, 2015). Conversely, ultrasound allows for soft-tissue evaluation without radiation exposure (Fontanarosa *et al*., 2022), but its accuracy and reliability are reduced when analyzing complex three-dimensional facial structures (Garib *et al*., 2010; Giangrossi *et al*., 2022). To address these limitations, facial scanners have been introduced, enabling precise diagnosis and treatment planning without radiation exposure.

Analysis of soft-tissue thickness by sex showed statistically significant differences across Class I, II, and III malocclusions. Specifically, in Class I malocclusions, males exhibited significantly greater thickness at Pg–Pg′ and A–A′ than females; in Class II, males demonstrated significantly greater thickness at Me–Me′ and A–A′ than females; and in Class III, males displayed significantly greater thickness at A–A′ than females. These findings suggest that men generally have thicker soft tissues in the lower face compared with women. Furthermore, in the overall sex comparison, males exhibited significantly greater thickness at Pg–Pg′, Me–Me′, and A–A′, whereas no significant difference was observed at Gn–Gn′. These results are consistent with previous studies conducted on Korean adults and Northwest Indian populations (Hwang *et al*., 2012; Thakur & Sehrawat, 2023), further underscoring the importance of considering sex differences in orthodontic treatment planning.

In interpreting these sex-based differences, it is important to consider underlying physiological factors that may contribute to variations in soft-tissue thickness. Sex differences in soft-tissue thickness may be influenced not only by skeletal structure but also by general body size (particularly height and weight) and subcutaneous fat distribution (Belzunce *et al*., 2023). Adult males generally have larger skeletal dimensions and greater muscle mass, whereas females after puberty tend to have a higher proportion of subcutaneous fat (Frank *et al*., 2019). These physiological differences should be taken into account when interpreting soft-tissue thickness data, and future studies should incorporate BMI and body composition analyses for more comprehensive evaluations (Karsli & Kutlu, 2023).

This study also revealed clinically significant findings regarding skeletal malocclusion classifications. Significant differences in soft-tissue thickness at Pg–Pg′ and A–A′ were observed between Class II and Class III malocclusions, with Class II malocclusions exhibiting the greatest thickness at Pg–Pg′ (chin region) and Class III malocclusions demonstrating the greatest thickness at A–A′ (anterior maxilla region). These findings are consistent with prior research conducted on Polish and Italian populations (Sforza *et al*., 2009; Kielczykowski *et al*., 2024), further supporting the importance of customized orthodontic treatment planning based on malocclusion type (Ackerman & Proffit, 1997). However, Gn–Gn′ and Me–Me′ showed no significant differences across malocclusion types, suggesting that these regions may exhibit less variability in soft-tissue thickness.

When comparing soft-tissue thickness between sexes and skeletal malocclusion groups, significant differences were observed. In the Pg–Pg′ region, Class I males exhibited greater soft-tissue thickness than Class I females, whereas both Class II males and females showed greater soft-tissue thickness than Class I and Class III females. In the Me–Me′ region, Class II males had significantly greater soft-tissue thickness than both Class I and Class II females. In the A–A′ region, both Class I and Class III males displayed significantly greater soft-tissue thickness than most female groups, with Class II males also showing significantly greater thickness than Class I females. However, no significant differences were observed in the Gn–Gn′ region across sexes and malocclusion groups. These results suggest that sex should be considered when evaluating skeletal malocclusion–related soft-tissue thickness differences, underscoring the necessity of customized orthodontic treatment approaches based on both skeletal classification and sex.

Although the present study did not include direct comparisons with CBCT-based measurements, previous CBCT studies have reported comparable trends in soft-tissue thickness variations across sexes and skeletal malocclusion classifications (Park *et al*., 2023). For instance, Park *et al*. (2023) found that males exhibited greater soft-tissue thickness in the chin and anterior maxilla compared with females, whereas Class II and Class III subjects showed increased thickness at the Pogonion (Pg–Pg′) and A Point (A–A′) regions, respectively. These findings closely mirror those of the present study, supporting the clinical validity of structured-light facial scanning for soft-tissue assessment. Furthermore, the scanner used in this study has demonstrated high accuracy and reliability in previous validation studies, particularly for facial applications (Lee *et al*., 2017). Given its noninvasive nature and absence of radiation exposure, structured-light scanning may serve as a practical and safe alternative to CBCT in orthodontic diagnosis, particularly in cases requiring repeated evaluation (Pellitteri *et al*., 2023). Future studies incorporating direct comparisons with CBCT data are warranted to further validate the diagnostic accuracy and clinical applicability of facial scanning technology (Kim *et al*., 2022).

Despite the significance of these findings, this study has several limitations. The sample size of 191 subjects may restrict generalizability, and the single-institution design may limit applicability to diverse populations. Future research should include a broader range of ages, ethnicities, and geographic locations, as well as longitudinal studies to quantitatively assess changes in soft-tissue thickness before and after orthodontic treatment.

In conclusion, structured-light scanning enables real-time, noninvasive monitoring of soft-tissue changes, reducing radiation exposure while enhancing diagnostic accuracy (Ferris, 2021). Future developments in digital orthodontics may allow clinicians to track soft-tissue adaptations dynamically throughout treatment, leading to improved treatment precision and patient outcomes (Kazimierczak *et al*., 2024).

CONCLUSIONS

This study demonstrated that facial scanners can be effectively used for orthodontic diagnosis by providing accurate three-dimensional soft-tissue data without radiation exposure. Significant differences in soft-tissue thickness were identified according to sex and skeletal malocclusion classification, with males showing greater thickness at Pg–Pg′, Me–Me′, and A–A′. In addition, soft-tissue thickness varied by malocclusion type, with increased thickness at Pg–Pg′ in Class II and at A–A′ in Class III. These findings highlight the importance of soft-tissue variability in treatment planning and suggest that incorporating sex and skeletal patterns into diagnosis may improve facial esthetic outcomes. The results support the clinical utility of facial scanners as noninvasive diagnostic tools and provide a foundation for future research with larger populations and expanded parameters to further refine personalized orthodontic treatment.

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RESUMEN: Este estudio tuvo como objetivo investigar las variaciones tridimensionales en el grosor del tejido blando facial inferior en función del sexo y la clasificación de maloclusión esquelética mediante un escáner de luz estructurada. La hipótesis nula fue que el sexo y la clasificación de maloclusión esquelética no afectan significativamente el grosor del tejido blando. Se incluyó a un total de 191 adultos coreanos (94 hombres, 97 mujeres) de entre 20 y 41 años. Se midió el grosor del tejido blando en puntos de referencia anatómicos clave mediante un escáner de luz estructurada (Morpheus 3D, Seúl, Corea) y se analizó en relación con la clasificación de maloclusión esquelética determinada mediante el análisis de Steiner. Los análisis estadísticos incluyeron ANOVA, la prueba de Diferencia Honestamente Significativa de Tukey, la prueba de Kruskal-Wallis y la prueba U de Mann-Whitney. Se identificaron variaciones significativas en el grosor del tejido blando facial inferior, basadas en el género y la maloclusión. Los hombres mostraron mayor grosor en Pogonion-Pogonion′, Menton-Menton′ y Punto A-Punto A′, en comparación con las mujeres. Entre las clasificaciones esqueléticas, se observaron diferencias significativas entre grupos. Los sujetos de clase II mostraron mayor grosor en Pogonion-Pogonion′ que los de clase III, mientras que los sujetos de clase III mostraron mayor grosor en Punto A-Punto A′, en comparación con las clases I y II. El sexo y la clasificación esquelética influyen significativamente en el grosor del tejido blando facial inferior, lo que subraya su relevancia en las evaluaciones anatómicas y la planificación del tratamiento maxilofacial mediante escaneo de luz estructurada.

PALABRAS CLAVE: Grosor del tejido blando; Escáner de luz estructurada; Maloclusión esquelética; Análisis cefalométrico; Diagnóstico de ortodoncia.

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